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METHOD FOR REMOVING COPPER FROM COPPER-CONTAINING IRON SCRAP
[Gando tetsu sukurappu kara no do jokyaku hoho]

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[Claims] /2*

[Claim 1] A method for removing the copper from iron scrap containing copper, wherein iron scrap mixed with copper or a copper alloy is impacted inside a rotary furnace while heating the scrap to a temperature between 380°C and 515°C in a non-oxidizing atmosphere with sulfur.

[Detailed Description of the Invention]

[0001]

[Technical Field of Applicability] The present invention relates to a better method for separating copper from iron scrap mixed with copper or a copper alloy such as scrap from metal cores, discarded transformers, discarded automobiles, electric motors or other machinery in order to recover iron or steel scrap with a high degree of purity.

[0002]

[Prior Art] Copper increases the hardness and reduces the elongation of iron and steel products. However, copper harms product quality by causing cracking and surface defects if the amount exceeds 0.3 wt%. Therefore, in order to reuse scrap containing copper from such sources as discarded automobiles, the copper has to be removed. In other words, the quality of the resulting steel depends on the elimination of copper. Many different methods have been proposed to remove copper from copper-containing scrap such as automotive scrap. However, these methods require a large amount of energy. It is also

* Claim and paragraph numbers correspond to those in the foreign text.

difficult to preheat and bind the scrap, and manual sorting is often required.

[0003] In order to solve these problems, one of the present inventors proposed a method for separating copper and obtaining pure iron scrap in which the separation efficiency was very high and energy utilization was low (Kokai No. 2-285035). In other words, it was a method for removing copper from copper-containing iron scrap comprising a first step in which iron scrap mixed with copper or a copper alloy is heated in a non-oxidizing atmosphere with sulfur to sulfurize the copper, and a second step in which the scrap is compressed or crushed to separate the embrittled copper from the scrap. Unfortunately, this invention requires a second compressing or crushing step to separate the copper. Thus, when the invention is applied to large-sized copper-containing iron scrap such as motor cores or discarded transformers, the sulfurization only occurs near the surface of the scrap under the sulfurizing conditions. This prevents sulfurization and embrittlement of the copper inside the scrap and prevents sufficient removal of the copper. In other words, the copper removal rate is poor in large-sized scrap.

[0004]

[Problem Solved by the Invention] The purpose of the present invention is to provide a method for easily and efficiently removing copper from iron scrap containing copper without using a second step such as compression or crushing.

[0005]

[Means of Solving the Problem] The present invention is a method for removing the copper from iron scrap containing copper, wherein iron scrap mixed with copper or a copper alloy is impacted inside a rotary furnace while heating the scrap to a temperature between 380°C and 515°C in a non-oxidizing atmosphere with sulfur.

[0006]

[Operation] The present invention can be used to effectively remove copper from large-sized copper-containing iron scrap such as metal cores and discarded transformers. The targets are copper and alloys containing 90 wt% or more copper such as copper wiring. Copper alloys such as brass and bronze are not targets. The mixture ratio of copper to iron ranges from 0.3% or less in low-copper scrap such as automobile scrap to 10-50% in high-copper scrap such as motor core scrap. If the copper to iron mixture ratio exceeds 50%, the copper can be effectively removed in a copper smelting step. The size of the scrap should range between 3 cm and 20 cm, but 3 cm to 3 mm is more appropriate for use with an impact material such as stainless steel balls. If the size of the scrap exceeds 20 cm, more time is required inside the rotary furnace. Scrap smaller than 50 cm can be used, but this adversely affects productivity.

[0007] As for the sulfurization and embrittlement conditions for the copper-containing iron scrap, the temperature range is 300-1000°C, the sulfur unit requirement is 1-100 kg/t, and the atmosphere is non-oxidizing. The sulfur unit requirement depends on the amount of copper mixed in with the scrap. The unit requirement is lower when the amount

of copper mixed in is lower. The sulfur is added directly to the reaction furnace using a power supplier and sulfur vapor is generated inside the furnace. This sulfur vapor can then be directed towards the scrap inside the furnace. Sulfur vapor can be easily obtained by heating the sulfur inside a sealed stainless steel container at a temperature between 300 and 550°C. The non-oxidizing atmosphere can be an inactive gas such as nitrogen or argon. However, from the standpoint of scrap heating efficiency, a combustible gas that does not completely combust is preferred such as CO or H_2 leaving behind 5-200% CO_2 or H_2O. In order for the sulfur-containing gas and scrap to make sufficient contact and react inside the furnace, the rotational speed is adjusted to 0.1 to 20 rpm while keeping the gas flow rate above 20 cm per second. However, the gas and scrap contact time begins to fall if the gas flow rate exceeds 10 m per second.

[0008] When the present inventors sulfurized and embrittled copper-containing scrap at temperatures between 300°C and 1000°C, they discovered that copper sulfide generated at temperatures above 515°C was not very plastic at high temperatures. As a result, the sulfurized layer on the surface was a dense layer that covered the surface of the scrap. In other words, the sulfur gas or reaction gas could not reach the interior of the scrap and the copper inside large-sized scrap remains unreacted.

[0009] In a motor core or transformer, overlapping copper wires are wound around an iron core. Sulfurization expands the area of the copper portion and prevents further infiltration of the gas into the

core. However, if the temperature is below 515°C, the resulting copper sulfide is sufficiently brittle and the purpose of the present invention can be achieved. If a small amount of impacting is performed while the reaction is occurring at a temperature below 515°C, the resulting copper sulfide can be separated from the scrap to expose the copper on the inside. This exposed copper is then sulfurized and embrittled by the reaction gas containing sulfur and then removed by the impact. The interior copper is gradually sulfurized and embrittled in this way. The impact force should have a drop of 10 cm or more, preferably 30 cm or more. A larger drop has more separating power, but there is a practical limit of 2 m or less because of the adverse affect of the impact on the materials constituting the rotary furnace.

[0010] If the reaction temperature is lower than 380°C, too much time is required to sulfurize large-sized scrap. Therefore, the reaction temperature should be 380°C or higher. The temperature should also be high enough to remove the enamel layer covering copper wire and expose the copper. The ideal temperature range from the standpoint of productivity and removal is between 400 and 500°C. Because sulfurized scrap is easily crushed moving towards the interior, the iron core can be completely separated from the copper.

[0011] If the reaction device is a rotary furnace such as a rotary kiln that moves the scrap around to create sufficient impact, the sulfurization, surface copper sulfide layer removal and crushing can be performed in the same chamber, and the copper-containing iron scrap can be removed as a mixture of iron scrap and copper sulfide.

The rotational speed of the rotary furnace should range between 0.1 and 20 rpm for reaction, impact and removal purposes. A lower rotational speed insufficiently mixes the scrap and lowers the impact frequency. If the rotational speed is too high, the scrap becomes stuck inside the furnace and the mixing and impact are insufficient. If the rotational speed is too high, the scrap also does not remain inside the furnace long enough and sufficient reaction time is difficult to maintain. Because the copper sulfide is discharged from the rotary furnace in powder form, it is easy to separate from the iron scrap using a sieve.

[0012] A higher impact force more effectively removes sulfides and thus increases the removal rate. The impact force is preferably increased by installing two to six agitating plates on the walls of a rotary furnace such as a rotary kiln or by introducing heavy objects such as iron blocks or stainless steel pellets. The agitating plates are preferably fins installed inside a rotary furnace with a height parallel to the rotational axis that is 0.5 to 3 times the length of the scrap. The heavy objects should be the same size as the scrap or smaller. If they are five times larger, the crushing force is too strong and the impact on the furnace is too high. The objects can assume any shape but angular objects have more crushing power. The heavy objects can also be pieces of scrap from large-sized motor cores and discarded transformers. Stainless steel pellets are preferred because they can be easily removed from iron scrap using electromagnetic separation and do not react at all with sulfur gas.

[0013] The amount of time inside the rotary furnace depends on conditions such as the size of the scrap, the reaction temperature, the amount of sulfur added and the impact force, but the amount of time usually ranges between ten minutes and one hour. If the amount of time inside the furnace is less than ten minutes, the heat and reaction are insufficient. If the amount of time is longer than one hour, too much of the iron is sulfurized and the sulfur concentration inside the iron scrap increases. After discharging the mixture from the rotary furnace and then heating or cooling the mixture, secondary crushing can be performed using a crushing device such as a ball mill or a hammer mill to improve the copper removal rate. Because the crushing device has much more impact force than the natural drop in a rotary furnace, copper that could not be completely separated inside the rotary furnace can be crushed and separated.

[0014] Sulfur is not added to the secondary crushing even when the crushing time is long. Because the film-like sulfur compounds adhering to the surface of the iron scrap is removed through secondary crushing, the purity of the iron scrap is improved. The impact force in the secondary crushing can be equal to or greater than the impact force in the rotary furnace. The secondary crusher can be a device with a strong impact and crushing force such as a shredder. In the present invention, the copper sulfide removed from the iron scrap is recovered in power form. The copper can then be recovered in a copper smelting step. Here, a spray-type continuous copper smelting furnace can be used.

[0015]

[Working Example] A mixture of motor core and discarded transformer scrap with an average copper content of 28% and a maximum length of 8 cm was added to a rotary kiln with stainless steel walls. Coke furnace gas was then incompletely burned and the resulting non-oxidized gas with a CO/CO_2 ratio of 0.25 was heated. The flow rate for the combustion gas was 1.5 nm per second. Sulfur with a particle diameter of 3 mm or less was continuously added to the combustion gas at a unit ratio of 100 kg per ton of scrap in order to generate sulfur gas.

[0016] Stainless steel plates were attached as agitating plates on the inside surface of the rotary kiln. Six fins with a longitudinal height of 10 cm were attached at equal intervals in the peripheral direction. The rotational speed was 12 rpm, and the average amount of time the scrap remained inside the rotary kiln was 40 minutes. The material discharged from the rotary kiln was sifted through a sieve with a 6-mm mesh. The material on top of the sieve was dissolved in the atmosphere. The reaction temperature was changed to within the 350 to 550°C range, and the material remaining on top of the sieve was added to a hammer mill. Secondary crushing was performed at 600 rpm and with a mesh of 30 mm, and the resulting material was magnetically separated. The results of the copper and iron separation are shown in Table 1.

[0017]

[Table 1]

Sample No.	Reaction Temp. (°C)	Secondary Crushing	Cu Conc. in Fe (%)	Cu Removal Rate (%)	Note
1	-		28	0	Raw Material
2	350	No	18	35.7	Comp. Ex.
3	350	Yes	16	42.9	Comp. Ex.
4	400	No	3.5	87.5	Working Ex.
5	400	Yes	0.2	99.3	Working Ex.
6	480	No	1.6	94.3	Working Ex.
7	480	Yes	0.2	99.3	Working Ex.
8	550	No	12	57.1	Comp. Ex.
9	550	Yes	6.5	77.8	Comp. Ex.

[0018]

[Effect of the Invention] The present invention can easily and effectively remove copper from copper-containing iron scrap such as the iron used in motor cores. Also, the removed copper sulfide can be recovered and chemically processed in order to recover and reuse the copper.